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ABSTRACT

In this document, the Organization for Economic Cooperation and Development (OECD) reports on the state of technical education in Europe, the United States, and Canada. It states that technical colleges are emerging as key institutions in technology-based education to fill industry requirement for more highly skilled and technically proficient workers. In France, the number of students entering programs to train higher technicians increased 150% between 1980 and 1992. Enrollments in higher technical education in the Netherlands increased by 40% between 1980 and 1990. The structure of educational systems varies dramatically across OECD member nations, and the missions and objectives of the institutions are not always the same. Nonetheless, they are all educating students to a level of technical education that succeeds compulsory education and precedes the baccalaureate degree. Nearly every technical college system was formulated or has been reformulated to serve both the student bodies and regional economies. In a 1995 survey of 100 United States colleges, 90% of respondents referenced economic development or modernization services in their mission statement. Colleges in OECD member nations are forming alliances with industry, economic development agencies, and with other colleges as well. The author concludes that the trend seems to be toward a more expansive role for colleges. (NB)

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Technical Colleges, Technology Deployment, and Regional Development

Organization for Economic Co-operation and Development
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Modena, Italy, May 1998

I. Introduction

Technical colleges are emerging as critical factors and key institutions in technology based development to fill industry's requirements for more highly skilled and technically proficient workers. "It is not the number of robots and computers, size and technical perfection of work centres or the degree of automation which will decide upon our future success," the Chairman of Volkswagon AG's Supevisory Board noted, "but our human resources."[1]

Evidence of rapidly growing demand in industry for technical workers with upper secondary or less-than-university tertiary education is based on changes and projections in enrollment and employment patterns, surveys of employers, and anecdotal information. In a 1994 *Fortune Magazine* cover story, "The New Worker Elite: Technicians are taking on a bigger role and commanding respect as the core employees of the Information Age," the authors projected increases in demand between 1992 and 2005 for engineering technicians of 19 percent; science technicians, 25 percent; and computer programmers, 30 percent.[2] Other indications of the pattern can be found in France, where the number of students entering programs to train "higher technicians" increased 150 percent between 1980 and 1992, and in the Netherlands, where enrollments in higher technical education increased 40 percent between 1980 and 1990.[3] In the United States in 1992, more than 28 percent of all workers had some college education, up from just 22 percent two years earlier.[4] Large employers working in many OECD nations, such as Intel, now request workers with tertiary degrees and contract with two-year colleges to offer associate degree programs inside their facilities.[5] Small employers trying to adopt new technologies, according to trade and employers associations, are increasingly seeking workers with post-compulsory education.

In conjunction with their education and training programs, technical colleges are proving capable of helping small and mid-sized businesses learn about and adopt newer technologies and techniques and generally become better connected and integrated into their regional production systems. Peripheral, education-related technology services and resources of the colleges have become increasingly important, particularly in rural and less advantaged regions.

This is largely a result of emerging views in the 1990s that the public sector ought to be more proactive in advancing the deployment of new technologies. In the early 1980s, the popular

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public sector role was transferring and commercializing technologies and innovations developed at universities and government labs and encouraging entrepreneurial companies. But it soon became evident that focusing on the latest technologies and university-based research neglected the large majority of the world's value-adding companies, the small and mid-sized enterprises, whose requirements for technology and innovation were for something less than cutting edge research and who lacked the capacities, capabilities, and connections to effectively adopt already commercially available technologies and proven production innovations (i.e., to modernize). In some less populated regions, these SMEs also were distant and isolated from support agencies and each other.

The need for technology and innovation among small and mid-sized enterprises (SMEs) was more apparent to regional technical colleges, which in many places are closer to local industry, more apt to be called upon to fill the increasing numbers of jobs that require upper secondary or tertiary but less than baccalaureate education, more flexible, and generally better positioned to help SMEs innovate and modernize. To meet that challenge, entrepreneurial technical colleges in many parts of the industrialized world altered or amended their core mission statements to enable them to address technology development and skill needs of companies in their regions.[6] This allows them to enhance and supplement their core education and training mandate and, in effect, function as "technology intermediaries", strengthening ties to industry, facilitating interfirm collaboration, performing technology and skill needs assessments and consultancies, and providing technical information—often in alliance with other service agencies and sometimes tailored to the specialized needs of regional clusters.

This paper will (a) establish the raison d'être for this emerging role for technical colleges, (b) suggest a taxonomy of education, training, and related activities that foster technology deployment, and enhance technopoles, with examples of each from OECD nations,[7] (c) describe the relationship of technical colleges to technology clusters that are emerging forces in public policy (based on recent case studies of four clusters), (d) discuss some of the obstacles to a more active role for technical colleges in technology based economic development, and (e) suggest roles for public policy.

II. Technical Education and Training Institutions in OECD countries

The institutions described in this paper are given a variety of titles—community colleges (e.g., Canada and United States), technical colleges (e.g., Denmark and United States), further education colleges (e.g., United Kingdom), technical and further education institutions, or TAFE (e.g., Australia), and polytechnics (e.g., Austria, Belgium, and New Zealand).[1] Yet they all have one feature in common, i.e, educating to the level of technical education[2] that succeeds compulsory

[1] Some of these institutions, such as in Ireland, Finland, and Germany, also confer baccalaureate degrees.

[2] International Standard Classification of Education (ISCED) 3 and 5

education but precedes the four-year baccalaureate degree (e.g., certificates, diplomas, and associate degrees). In Europe there is another set of institutions that are more advanced but also operate in the nexus between university and compulsory education—fachhochschulen in Germany, hogeschools in the Netherlands, and regional universities (formerly polytechnics) in the United Kingdom. These regional technical colleges teach more advanced levels of education than, for example, American community colleges or Danish technical colleges, but in a much more applied fashion than classical universities. A third set of technical colleges (e.g., Institutes of Technology in Ireland and Finland) span the full range from one, two, and three year degrees to full four-year and masters's engineering degrees.

Let it be clear that the distinctions among national systems of technical colleges are more than names. The structure of educational systems varies dramatically across OECD member nations, and the missions and objectives of the institutions under discussion are not the same. There are differences among nations in levels of degrees conferred, scope of missions, and range of responsibilities. One distinction is between those colleges that offer only formal education, usually to national standards and qualifications, and those that are additionally responsible for non-credit work force development and customized training for industry.

In some nations, the technical college is responsible for both education and work force development; in others, the two are delivered through different agencies and institutions, one under the Ministry of Education and the other under the Ministry of Labor. In the U.S., Canada, Ireland, and England, for example, community colleges are authorized to deliver (but are not the sole provider) of non-credit work force training to companies. In Denmark, Ireland, Sweden, and Austria separate agencies are responsible for non-credit education and training—AMUs in Sweden and Denmark and FÁS in Ireland operate under their respective Ministries of Labor, and Wirtschaftsforderungsinstitute der Handelskammern (WIFIs), or Economic Promotion Institutes, are part of the Economic Chambers in Austria. The structure of the systems affects the breadth of the colleges' support of technology deployment; those that offer non-credit education generally are less constrained from providing related non-education services.

Another distinction is between institutions that offer only pre-baccalaureate education (one-, two-, and three-year degrees) and those that also are qualified to offer baccalaureate education (four- and five-year degrees). In Austria, Ireland, Finland, and Germany technical colleges or institutes and polytechnics confer bachelor of science (BS) or arts degrees which, though often more applied, are roughly equivalent to a first university degree. In Canada, New Zealand, and the United States, technical colleges are limited to awarding associate degrees or certificates. The higher the degree offered, the more likely the institution is to have R&D capacity and shift its priorities from technology deployment to technology development and transfer.

A third difference is the extent to which the technical college bridges the gap between education & training and acts as a technology intermediary. Four factors appear to affect the range of modernization services: government regulations, comprehensiveness of the institution, availability of related services for SMEs from other sources, and demands of industry. For

example, some technology centers in which students are trained also can be used by industry to study new technologies or pilot test new processes, but some states and nations prohibit commercial use. In the Netherlands, Great Britain, Germany, and Denmark, other agencies, such as the Danish Technological Institute and TNO, have extensive technology support services for SMEs. This allows the colleges to focus more narrowly on education and training.

In the U.S., where services for SMEs are still quite new and relatively small in scale, community colleges play a more aggressive and proactive role. Aided by advanced equipment manufacturers eager to increase market demand for their products, a number of community colleges have built and equipped sophisticated technology centers to both demonstrate and train for the newest manufacturing and computer technologies. The National Coalition of Advanced Technology Centers (all of which are based at community colleges) has more than 100 member institutions and a full-time representative at the National Institute of Standards and Technology, the federal agency that supports programs for technology diffusion in the United States.

Yet taking into account the numerous distinctions, the regional technical colleges have certain critical commonalities. They are upper secondary or tertiary institutions that are more applied than universities, target the broad categories of occupations classified as technicians and engineers, and function primarily for the benefit of economies and people residing within their economic regions. Therefore, to simplify the ensuing discussion of how they support and encourage technology deployment and modernization, this broad array of institutions will all be referred to as "technical colleges".

III. Technical Colleges in a Technology Based Economy

Technical colleges are unusual and even unique among public educational institutions in the explicitness and intensity with which their economic aims complement their educational goals. Nearly every technical college system was formulated or has been reformulated to serve both the student bodies and regional economies. This economic value of technical colleges is based on an inherent flexibility that allows them to respond quickly to the demands of the workplace caused by growth, technology, and/or economic readjustment. Over time, the most entrepreneurial and innovative of the colleges have used their resources and expertise not only to react to technological change but also to influence rates of technology adoption. The (a) missions and goals, (b) regional focus, (c) knowledge base, (d) acknowledgment of interdependencies between modernization and skill levels, (e) flexibility, and (f) contributions to social capital all reflect the impacts of technical colleges on economic and technology policy and the effectiveness of their services affect the outcomes.

A. Has Economic Development Mission

Economic development, long a silent partner of technical education, is now making its voice heard. It has become a core mission of the technical college, promoting inward investment and the expansion, retention, and modernization of existing industries. In most U.S. states,

community colleges have cooperated with regional economic development agencies and participated in their planning and recruitment activities for decades. British experts note that perhaps the biggest change in the British education system "has been the incorporation of FE [Further Education] Sector Colleges, marking them out as powerful locally based agencies with a key mission, in terms of skills, but with an ever widening scope to contribute to local and regional economic development in their own right".[8]

When Regional Technical College Galway (renamed in 1998 Galway-Mayo Institute of Technology) opened in 1971, it defined a three-pronged mission: (1) rural development, (2) industrial competitiveness, and (3) better education and training. The 1989 Report of the Commission on the Future of the North Carolina Community College system identified as one of six strategic challenges "help business and industry adapt to technological change and promote small business development throughout the state."[9] In 1993, a strategic plan developed by Oklahoma State University's technical college at Okmulgee named as its number one goal "to expand the institution's role in Oklahoma's economic development." Objectives included fostering program development on advancing technologies in value-added industries that require and reward technicians and professionals; expanding "continuing and customized education, contract training, technology deployment-demonstration-assistance and utilization", (e.g., fostering "networks of small- to medium-sized firms to facilitate technology modernization" and establishing "on-going relationships with private and public agencies engaged in economic development").[10]

The few plans cited are examples that illustrate the degree to which technical colleges have absorbed and internalized the goal of technology-based economic development in their institutional psyches. In a 1995 survey of 100 U.S. colleges, 90 percent of respondents referenced economic development or modernization services in their mission statement.[11] Even colleges that have chosen to remain truer to a more narrowly defined education and training mission are paying more attention to skill upgrading and strengthening their connections to business and industry and accelerating their responses to its technological and workplace demands.

B. Focus on Region

As regional institutions, the programs and services of technical colleges are intended for local and commuting students and nearby firms. Faculty are encouraged to think globally but act locally. This regional focus presents the technical colleges with the opportunity for cluster specialization, which some colleges have seized (see Section V). In contrast, flagship research universities, which produce more scientific and technological innovations, are central to—and often indeed define—their local economies. But they are in effect a resource of the larger state or nation for economic developers widely disseminating their research products and knowledge. Universities attract students from and send graduates all over the world (over half of the Ph.D. candidates in math and science in the U.S. are non-U.S. citizens). Their expertise is more likely to reflect the

interests and expertise of faculty rather than regional business demand. Thus, the home regions of universities capture only a small fraction of their aggregate economic benefits.

C. Acts as Repository of "Know-How" for SMEs

The widely decentralized and applied technical colleges, in many regions, are the leading source of technological expertise and know-how and the core of regions' knowledge infrastructure. A recent technology plan for Limburg, Belgium, for example, asserts that Venlo Polytechnic is "the most important knowledge centre in the northern part of the province".[12] Technical colleges are particularly helpful to SMEs, which, as a result of the downsizing of industry over the past decade are increasingly important to regional economies. Technical colleges are better positioned to reach the SMEs than universities, consultants, and service agencies, many of which prefer not to bother with "know-how" needs that may not be technologically challenging or of a scale that can be sufficiently profitable.

Although technical colleges, admittedly, have paid more attention to large employers than SMEs, they are fundamentally more accessible and less intimidating than universities to SME owners who rarely hire the graduates or use the extensive resources of universities.

D. Relates Technology Adoption to Skill Requirements

It is virtually impossible for employers to separate their needs for investments in new technology from investments in training and skill upgrading. A Danish study of problems firms had experienced introducing new technologies found that "lack of qualified labor" was highest (43%).[13] Three out of four rural manufacturers responding to a survey conducted by the U.S. Department of Agriculture in 1997 reported quality of labor at least a minor problem and one in three reported it a major problem.[14] As the European Union's ADAPT program publication notes, "Since innovation cannot take place without suitably trained personnel, successfully adapting the workforce to change is an important way of increasing competitive advantage."[15] While many firms rely on the companies from whom they purchase equipment for training in the use of the equipment, they realize that applications of new equipment generally go hand in hand with changes in process and management, and that the training requirements are much broader than those offered by the suppliers. Thus, any investment in new technology requires a concomitant investment in education and training.

This relationship became readily apparent at the start of the U.S. government-supported modernization initiative. The first manufacturing technology centers, quite unexpectedly, chose to partner with technical colleges to build their contacts with SMEs in order to address work force development and education training in parallel and unified with technology and management needs. Moreover, new employees familiar with the latest technologies and techniques can become in-house catalysts and, as they acquire more authority, can influence rates of adoption by employers. In national systems with a tradition of apprenticeship or internships such as Austria and Denmark, hands-on experience with technology is acquired in the firm.

E. Exhibits Flexibility and Adaptability

In many nations technical colleges are younger than other educational institutions. They have fewer traditions and a less rigid organizational structure. For example, Ireland's regional technical colleges were formed in 1972, Finland's polytechnics in 1992, and the United Kingdom's further education colleges were incorporated that same year. Consequently, they are less resistant to change, making it easier for those with explicit economic development goals to respond to changes in local labor markets. Functioning as the institutions most often called upon to support inward investment with customized training for the businesses, they have had to remain responsive to industry needs. Researchers have found that in plant location decisions, the availability of highly skilled and/or qualified labour is not nearly as important as an education and training system capable of supplying skills in the long run.[16] A number of traits contribute to the flexibility:

- faculty are less regulated than in universities and freer to participate in commercial activities;
- new programs can be introduced more easily and quickly, and can be customized to local technical skill needs;
- faculty are highly likely (required in some countries) to have industrial experience and maintain industry contacts or industrial employees who teach part-time;
- the work experience components of technical education require continual monitoring of workplace;
- industrial technical committees and advisory boards are involved in curriculum development and
- industry may design final projects and exams and assess performance.

All of these contribute to the institutions' responsiveness to changes in technologies and skill requirements.

F. Fosters Associative Behavior

Perhaps the most under-rated and undervalued contribution of technical colleges to technology based development is its nurturing of social capital by facilitating interaction and learning among people in different organizations. Intermediary institutions in regions play important roles in putting companies and services in touch with one another and encouraging technology transfer and information exchange. Technology is diffused most effectively through personal contact and companies learn best from other companies. Faculty who are well-connected to industry become the purveyors of the "untraded transactions" that represent technology and knowledge transfer and diffusion. The technical college provides SMEs with their best source of information and best de facto human resource department for the firm too small to support a human resource development function internally. Colleges provide neutral environments for association—through evening continuing education programs, symposia and meetings, CEO breakfasts, and other social/professional/educational events in which local business people have a chance to discuss common economic issues. The entrepreneurial college understands the value of

associative behavior and assumes roles as broker and facilitator. The more pro-active colleges have organized business alliances to intentionally accelerate learning, collaboration, and business transactions.

IV. Technical Colleges, Skills, and Technology Diffusion

Once it became apparent that SMEs have a diversity of technology needs, and that technology deployment requires higher level skills than what is generally acquired during compulsory education, demands on technical colleges grew. This elevated them to a stronger and indeed more critical role causing enrollments to rise, programs to expand, and budgets to grow. Beginning in the 1980s, some of the more innovative colleges began to realize that they could both influence the rate of technological change and demand for their programs and, at the same time, generate revenues, by directly marketing the technological resources of the colleges and staff expertise. Colleges complemented and supplemented their education and training programs with non-credit skill upgrading, management training, education and training related consultancies, and services that utilized their teaching equipment such as testing, applied research, and new equipment demonstrations.

This expanded set of services matches the expanded mission, and creates new roles for technical colleges. The United Kingdom's Further Education Development Agency (FEDA) suggests tripartite roles:[17] (1) service provider, (2) strategic partner, and (3) stakeholder. A report notes that "the current era has seen a multiplication of roles to include everything from a key role in business start up programmes, to FE as an 'engine' of urban regeneration in inner cities".[18] A survey of 101 tertiary institutions divulged the activities and rates of participation shown in Table 1. A 1995 study of technical colleges in the U.S. identified eight types of technology related activities: (a) industry hub, (b) technology center/teaching factory, (c) incubator and catalyst, (d) educator, (e) customized trainer, (f) extension service, (g) broker/facilitator, and (h) partner.[19]

Table 1
Percent of UK Tertiary Colleges in Partnership with Business, Number per Annum

	No. of Businesses			
Activity	**1-50**	**51-200**	**201-500**	**Over 500**
Training	25	24	24	19
Work Placements	15	37	26	14
Consultancies	68	12	0	0
Research	63	2	1	0
Education Business Partnerships	60	14	2	2
Planning	58	8	2	1
Technology	47	16	5	2
Networking	38	19	13	3

Source: Simon James and Greg Clark, *Investing partners: further education, economic development and regional policy* (London: Further Education Development Agency, 1997).

The classification scheme used in this paper draws upon the U.S. taxonomy and FEDA's economic development categories to encompasses the activities at technical colleges that relate to or support technology adoption and diffusion. The categories and the elements that define them are shown in Table 2.

Table 2
Categories of Activities at Technical Colleges

Education: Gateway to the workplace	• Rigor, articulated with higher education • Comprehensive programs • Working with industry • Targeting Clusters • Educating disadvantaged youth • Effective recruitment
Upgrading skills and retraining: Adapting to technology	• Customized and contract education • Forming training networks • Using distance learning • Teaching soft technologies/skills • Educating managers • Training displaced workers
Technology Intermediaries: Accelerating deployment	• Technology centers / teaching factories • Technical assistance • Industry sector hubs • Host for technology services • New business incubators
Fomenting strategic alliances: Learning companies and learning communities	• Forming alliances with industry • Consortia with other colleges • Cooperating with development agencies • Facilitating intra-firm learning

What a specific college actually offers depends on the scope of its mission, the range of its mandate and authority, access to resources, and availability of alternative services. Colleges in areas rich in technological resources are more likely to limit their services to selected niches where they are most competitive. Conversely, colleges in areas with few technological resources assume greater roles and offer more services. Descriptions of each role are illustrated with innovative and exemplary examples from OECD countries.[3]

A. Education: Gateway to the Workplace.

The most common and important contribution—and unquestionably the core mission—of

[3] A number of the examples are drawn from members of the Trans-Atlantic Technology and Training Alliance, an alliance of 29 technical colleges in the U.S. South and Europe, managed by Regional Technology Strategies and Scottish Council for Educational Technology and dedicated to innovation, experimentation, and dissemination in the area of technical education and services.

technical colleges is maintaining a sufficient flow of appropriately skilled and credentialed individuals into the work force to feed a manufacturing base that is looking for higher than compulsory education but not necessarily university credentials. The Chairman of CBI Scotland expressed a frequently heard concern at a World Skills Conference in Glasgow in 1995: "It's not that our top skills aren't the best, more that our mid-range skills are uncompetitive."[20]

There are a number of indicators of a growing preference among employers for these intermediate credentials. One is unemployment rates. Although unemployment rates are much higher for young people without higher secondary or tertiary education, the difference between unemployment rates of people with non-university tertiary and university education was negligible in 1992 and was lower among youth with non-university tertiary education for most countries in 1995 (see Table 3). A second is the rising enrollments of degreed people in the technical colleges, especially in the United States. North Carolina's community college, for example, is a net importer of people with university degrees, with a larger number of university-educated people enrolled to acquire new job skills than the number enrolled in order to prepare for a university degree. The third is the view of employers themselves, with an increasing number of larger companies now specifying intermediate credentials.

Other distinguishing features of various technical college systems are the application of skill standards, degrees of specialization, academic rigor and concomitant opportunity for further education, catchment areas, means for attracting students, and the demography of the student population. A few of distinctive features between North American and European systems (generalized because there are differences within North America and within Europe) are shown in Table 4. At effective colleges industry and labor participate in improving and updating curriculum to keep up with changing industrial requirements. Colleges make special efforts to attract high school youth into technology programs and place special emphasis on underrepresented populations. The following are ways that colleges prepare the work force for more technologically demanding responsibilities.

Table 3
Unemployment Rates for Persons with Tertiary (Postsecondary) Education, aged 25 to 34, 1992 and Persons aged 25-29, 1995

	1992		1995	
Country	**Non-University Tertiary**	**University**	**Non-University Tertiary**	**University**
Belgium	3.1	3.4	4.8	5.7
Denmark	7.2	7.8	6.6	7.7
France	5.6	6.8	8.4	13.8
Germany	4.6	4.3	4.9	5.1
Ireland	6.4	5.0	6.4	5.4
New Zealand	5.6	5.0	5.4	2.9
Spain	16.7	17.5	23.7	33.2
United States	5.7	3.0	3.7	3.0
OECD Country Mean	5.9	6.0	7.9	8.5

Source: Centre for Educational Research and Innovation, *Education at A Glance: OECD Indicators*, Paris: Organization for Economic Co-operation and Development, 1995 and 1997.

Table 4
Generalized Contrasts* between North American and European**
Formal Technical Education Models

As in North America	As in Northern Europe
• Returning to school	• Continuing directly from formal education
• Part-time students, in work force	• Full-time students
• Most students over age 25	• Most under age 25
• Terminal	• Articulated with higher education
• Technology in school	• Technology in workplace
• Acquiring skills, exploring career options	• Pursuing credentials
• Credential has limited market value	• Credentials recognized by employers
• Large, comprehensive colleges	• Smaller, specialized colleges
• Inconsistent national standards***	• Accepted national standards
• Focus on improvement and economy	• Focus on design and creativity
• Governed by trustees and educators	• Governed by social partners

* These do not cover all systems in each continent
** As represented, for example, by Austria, Denmark, Ireland, Great Britain, Germany, New Zealand, and Sweden.
*** Standards under development

1. Rigorous, articulated with higher education, but based on realities of industry

Adding more rigor to technical curricula opens doors to higher levels of education. Vocational-technical programs have had the reputation, perhaps because they are very applied, of being insufficiently challenging academically. Consequently, they have been considered inferior to academic tracks, accorded a lower status, and generally are educationally terminal. Recent reforms designed to increase transferability between vocational and academic and enable continuation to higher education have required raising standards. One result of raising standards and expanding options is a reduction in the stigma associated with vocationally oriented programs and elevation of stature in the eyes of prospective students and parents. However, higher standards can limit access for many lower achieving students who need an applied, less academically challenging, vocational educational setting to reach their potential. One compromise position taken in many places is to combine high standards with sufficient remediation and earlier job paths for less advantaged students.

- Aldini-Valeriani Technical Institute in Bologna, **Italy** is a 154-year old technical school founded by a physicist and an economist for industry and to help rebuild the local economy. The college's intense program combines theory (half) with practice in school (half)—but with

a gradual shift toward more theory, and less hands-on practice because, as the president notes, "technology is changing too fast and the hands-on skills become obsolete too quickly". Local firms want more theoretical knowledge from their entrants because they look to them for technological advances, and they are willing to provide specific skills on job. However, the programs do emphasize quality, and have advanced testing equipment, and design, both of which is considered a regional competitive advantage. Graduates are able to transfer into engineering programs, and many do.

- In **Denmark**, EUC-Syd offers a technical technician's program with high academic standards for the local electronics industry. During the first year, students in the two-year certificate programs take the same courses as students enrolled in the three-year HTX program, allowing students to transfer to the engineering program. From there, they are prepared to either go into the work force or university.
- A typical eight-hour school day in the Micro Electronics Systems Design program at Haque Hogeschool in the Hague, **Netherlands** includes two hours of classroom education, three hours on a study project (for five days per week, 42 weeks per year), and, by the second semester, three hours on a real project, on a team led by a graduate student and a problem specified by a company. The reason for the heavy emphasis on practical experience is that the school has found that SMEs want a well-rounded and flexible engineer who knows how to take a project from design through production, work with suppliers, and meet deadlines, not a technically proficient specialist.

2. Comprehensive programs

Advances in technologies is causing colleges to consolidate what had been narrowly specialized technical programs into broader occupational classifications and to intregrate more academics. This is a response to industries that now ask for graduates able to adapt more easily to change. It leads colleges to place greater emphasis on "soft" skills such as communications and cooperation, languages, and on generic technical skills. For example, Chelmsford College in England is offering a wide range of modern languages, including Japanese, Chinese, Russian, and German, to employees of companies that require language proficiency, which has raised the profile of the college in the business community and expanded its market in the private sector. In European education systems, the result has been a reduction in the number of career paths and more emphasis on less technical competencies.

- Integrating entrepreneurial and technical education is a focus at the Technical College of Jutland in **Denmark**. Working in cooperation with German and Spanish colleges, it developed electrical studies courses that improve problem-solving abilities, strengthen cooperative skills, convey knowledge of management and business decisions, and spark interest in entrepreneurship.

- Kuopio Institute of Technology's Virtual Factory in **Finland** combines theory and practice in a simulated business environment. Team work and information, material, and cash flows have practical meaning for students in Virtual Factory as they plan and implement factory

operations. Logistics, product development, marketing and sales, and manufacturing all find application in the Virtual Factory. Students practice concepts such as concurrent engineering, action-chain management, supply-chain management, and team work in a real-world environment. Virtual Factory allows engineering students to investigate alternatives and see real-life consequences for their factories. A final measure is the profit they have earned, which they then compare against results of competing factories. Kuopio's Virtual Factory helps instructors motivate students to discover the essential links in an exciting educational environment that develops well-rounded thinking and real-world behaviors.

3. Working with industry

Social partnerships, common in some of the older European systems, offer a structure for formally involving industry in technical education. Technical colleges depend on that relationship to ensure that the skills and knowledge are relevant to current and future needs. In Austria, for example, vocational schools work hand-in-hand with the industry associations of the Chambers of Commerce and their training centers (WIFIs), with the business organizations helping to develop curricula and establish skills standards. The Chambers set skill standards and assess competencies of completers. Some of Austria's new fachhochschulen have been established by Chambers. But in nations where traditions of cooperation do not exist, it is up to local institutions to involve industry.

- In Toronto, **Canada**, Humber College of Applied Arts & Technology is part of a partnership with government, labor, and the plastics industry to form the Canadian Plastics Training Center. Programs include a certificate program for process operators and injection molders, a two-year degree for plastics engineering technicians, and broad continuing education for the industry. It is autonomous but governed by four upper-level college administrators along with industry and labor representatives.

- In Ieper, **Belgium**, Technisch Instituut Heilige Familie, along with local SMEs, established a CAD/CAM training center at the school for the ready-made clothing industry. The Center was the result of the college and SMEs jointly recognizing the industry needs to adopt the new technologies but lack of appropriate skills within the companies. The center has attracted new companies and now also addresses a wide range of complementary technical needs such as internal and workplace organization and job qualifications.

4. Targeting Clusters with Specialized Programs

Achieving excellence under constrained resources requires colleges to make choices in their programs. Colleges must balance the broad based interests of their students and the broad spectrum of local businesses with the specialized and more concentrated needs of particular engines of the regional economy. Some colleges choose to focus their resources on specialized areas either a response to higher levels of demand in an existing cluster or to catalyze and nurture a promising cluster.

- Ayr College of Further Education in **Scotland** last year inaugurated Edutronic, its state-of-the-art Electronics Training Centre. Jointly backed by the college and Enterprise Ayrshire and with supplementary support from the European Regional Development Fund, it is the first college-based program in Europe equipped with a Surface Mount Technology production line. The centre will offer programs ranging from graduate engineer workplace introduction courses to equipment specific courses. It was developed as a result of research into the skill needs of the Scottish electronics industry, which accounts for 15 percent of all manufacturing employment in Scotland (7,000 in Ayrshire alone). Some of the equipment has been provided by Panasonic, a large local employer.

- Nelson Polytechnic in **New Zealand** is located in the seafood capital of the country, a cluster that includes high tech fishing fleets (Sealord's newest boats are $25 million investments and include the latest technologies) and equipment, seafood processors, distributors, and R&D. The school attracts senior managers throughout the South Pacific to its seminars and management education and fosters networking. The polytechnic established a separate facility for the industry in 1976 and offers certificates and diplomas in seafood technologies, fisheries technologies, marine farming, and statutory marine certificate courses. Last year a group of students began a pilot program developed jointly by Nelson Polytechnic and Sealord Fishing Company that includes an apprenticeship period on the wharves and at the fisheries.

5. Serving disadvantaged youth

Vocational education in technical colleges offers a way to engage and retain youth in school who have not succeeded in traditional academics and improve their earning capacity. One U.S. researcher finds that in most states between one in four and one in two entering students test below college standards in the basic skills.[21] This includes youth who come from disadvantaged homes, are underachievers, or have a different native language. But using vocational education as a "second chance" educational opportunity presents a dilemma for colleges that want to maintain high academic standards while also providing an open and revolving door for youth who may have dropped out of school and are too old to comfortably re-enroll in secondary programs. Colleges often address this with remedial programs that will provide a lower level certificate but also a path to higher levels for those who work hardest.

- Anniesland College in Glasgow, **Scotland,** working with the local economic development agency, Drumchapel Opportunities, and with European Union funding, established a learning centre in a disused supermarket near a large public housing project in the centre of Drumchapel, a community of about 25,000 on western periphery of the city. The community includes a high proportion of single parents and unemployed adults, many of whom have low qualifications. Those who are employed have largely low-paid jobs. The college offers entry level learning programs on a flexible timetable and with childcare facilities. Several thousand have now gone through the learning centre, and many progressed to programs for higher qualifications at the College's main campus some four miles from

Drumchapel. Few, if any, of the students who progressed to higher-level and technical programs would have done so without the centre.

- In 1995, Pontypridd College in Wales (**UK**) initiated the "Youthstart Project" to extend and transfer a flexible curriculum model designed to enable disaffected and disadvantaged young people to enter the labour market. The curriculum model targets basic skills of literacy, numeracy and information technology within a vocational context prior to labour market entry. It was developed at Pontypridd College with support from EUROFORM and PETRA and ESF projects. The project has now transferred the model to European member states by involving transnational partner institutions.

6. Effective student recruitment

Throughout the OECD countries, skills shortages have emerged as significant barriers to growth. In 1991, the EU's Industrial Research and Development Advisory Committee recognized the problem stating that "skill shortages are growing, particularly in generic technologies, electronics and information technology, systems engineering, biotechnology, and advanced materials."[22] A 1997 US study noted a shortfall or 190,000 information technology workers. And in a 1997 survey conducted for the U.S. National Association of Manufacturers, 63 percent of the responding companies said finding qualified workers was a problem.[23] Although low birth rates are part of the problem, the bigger issue is a mismatch between supply of entrants into certain programs due to lack of interest and perhaps information (i.e., low enrollments in industrial technologies) and demand. There has been an accelerating reluctance of youth to choose technical career paths. Some colleges have taken steps to attract youth.

- In Wales, **UK**, Barry College has started "Saturday Clubs" in cooperation with British Airways to attract more capable people into engineering technician programs. Its target is 14-year old youth, who are given an opportunity to work in the shops, visit the British Airways maintenance facility, and go for short flights. The series of sessions is intended to let them experience engineering in an aerospace context.
- Oklahoma State University—Technical Branch at Okmulgee in the **US** will run its fourth annual two-week Summer Youth Academy this year, designed to make the state's young people and their parents aware of the high-skill, high-wage job opportunities available in modern manufacturing. The Academy exposes 14 and 15 year olds to what it is like to work in an advanced manufacturing company. The demand has increased to where there are three to four applicants for every opening. Students take technically-oriented courses, gain exposure to computer-driven machinery and visit local firms.

B. Upgrading Skills and Retraining: Adapting to Technology

Technology is forcing the old but elusive ideal of lifelong learning into reality. Retraining and skill upgrading are now considered not only a right but a need and social duty. The EU's IRDAC states that "continuing education should become a mainstream activity of the higher education sector."[24] Three of eight companies responding to a 1998 survey by the U.S. National

Association of Manufacturers believe their current workforce lacks the skills to upgrade technologies or introduce productivity improvements.[25] In another 1998 survey—of 425 "trendsetter mid-sized U.S. companies—69 percent said "lack of trained workers" was a barrier to business growth in the next 12 months, up from 50 percent in 1996 and 29 percent in 1994.[26]

Nearly every technical college offers continuing and contract education, usually in the evenings to accommodate working students and businesses. (One distinction between continuing and contract or customized education is that the customer for the former can be an individual or business but for the latter, only business.) The 1998 survey for the U.S. National Association of Manufacturers also found that companies that outsource continuing education and training turn first to public community colleges (66 percent) and next to private technical colleges (60 percent), with universities far behind (26 percent).[27] Another survey of companies in the U.S.—by the American Society for Training and Development—found that 33 percent used technical and vocational colleges and 30 percent used community colleges to provide training.[28] As a result, non-credit continuing education and contract work force training—particularly for new and expanded industry—are now common functions of technical colleges. It is also increasingly common in firms undergoing technological changes; whereas companies once relied on the equipment manufacturers and consultants for the majority of their training with new technology, they now look to colleges to provide more comprehensive knowledge of both the equipment and related effects on the production processes.

The use of education funds is not allowed for non-credit courses in some systems. Therefore, colleges must rely on other sources or charge fees. Customized training, for example, is typically paid from economic development funds and often matched by company fees; contract education paid for by the firm; training of displaced or disadvantaged workers is funded by Departments or Ministries of Labour; and short-term training programs and seminars are financed by participants' or company fees.

Each of these is offered in highly competitive markets that include for-profit training companies, equipment manufacturers, public training institutions, union and company training, and consultants. Thus, colleges must be able to offer high quality, price-competitive programs and document results.

1. Customized and Contract Education

A 1994 survey of U.S. community colleges found that about 90 percent offer contract training, with the median number of students enrolled in a college about 1,100 FTE.[29] Thirty percent of the programs—those that were most active—were housed in separate specialized units within the college. One of the most distinctive and direct economic development efforts is customized training. It was instrumental in drawing manufacturing to the U.S. South in the 1960s and 1970s and vital to the recent successful inward investment strategies of Wales and Ireland. With customized or contract education the employer, or customer, influences the content, provides some of the materials, selects those who will be enrolled, and may even provide the training site and do some of the teaching. The nature of the customized training, however, is changing as

technology advances and companies become more dependent on employees' knowledge. Once used mainly to instill good work habits and teach company policies, training for more skilled work now includes, for example, quality control processes, team building, and problem solving.

- In 1987, the Okuma Machine Tool Company in Oguchi, Japan, decided to establish a production facility in the United States due to import restrictions on CNC machinery, and Charlotte, North Carolina, **US** was one of the potential sites. Central Piedmont Community College was included on the regional development team charged with attracting the investment. The college's new industry program crafted a plan for start-up training and continuing manufacturing training. The relationship continued over the years, culminating in 1994 with the Central Piedmont Community College - Okuma Technology Institute, which last year served 37,000 students. The college manages the operation through its Corporate and Continuing Education Division, hires faculty, schedules classes, markets the institute outside of the company, and evaluates programs. Okuma provides classroom space and labs and access to equipment and assistance with course scheduling, context, and selection.[30]

2. Forming training networks

SMEs have not taken full advantage of customized and contract training programs. They lack sufficient scale to justify costs of customization and many are reluctant to request and invest in training due to fear of losing their more skilled employees to higher paying larger companies. To reduce their costs and improve employees' opportunities by establishing career ladders, some colleges have resorted to collaborative approaches, i.e., organizing firms with similar needs together into business networks. The networks serve the dual purposes of allowing SMEs to acquire services at lower costs and creating learning communities among companies.

- The AIWA Skills Training Partnership, sponsored by five Welsh Training and Enterprise Councils and the Welsh Development Agency, is an example of a new regional strategy in Wales, **UK** for improving the quality, thereby increasing the numbers, of local suppliers to large employers like AIWA. Barry College, a further education institution near Cardiff, is key to the partnership. An advisory and consultancy company affiliated with the college serves the training and upgrading needs of the area's businesses and industry. The firms identified and short-listed by AIWA's purchasing team were analyzed by the WDA, Barry College, and AIWA, following which AIWA's director inform them of its processes, plans, and requirements for utilizing local suppliers. The Wales Quality Center, working with the college, conducted the actual training.

- Faced with skill shortages of skilled machinists, Springfield Community Technical College in Massachusetts (**US**) and the National Tooling & Machining Association and the college established an apprenticeship based training network among SMEs called MechTEC. Students rotate among SMEs to learn broaden their exposure to production methods and technologies in different working environments. The college provides the classroom theory. Apprentices work toward an associate degree with an option to transfer into an engineering program.

3. Using distance Learning

Colleges are increasingly turning to computer-based, distance learning methods to reach students unable to attend on-site classes. The United Kingdom's Open University has been one of Europe's most comprehensive programs, but today every nation relies on computers to deliver education and training in some fashion. Recently the UK also launched another employer targeted distance learning concept called the "University for Industry". The Asynchronous Learning Network (ALN) is one of the newer distance learning applications. It maintains the integrity of the class by introducing the internet as a medium for peer to peer interaction among students and between students and instructors. ALNs make it possible to retain the benefits of group learning and team projects without requiring classrooms and to reach students unable to be on-line at the same time.

- In a project funded by the Alfred P. Sloan Foundation, Galway-Mayo Institute of Technology in **Ireland**, EUC-Syd in Sønderberg, **Denmark**, Trident Technical College in South Carolina (**US**), and West Virginia University-Parkersburg (**US**), all members of the Trans-Atlantic Technology and Training Alliance, are offering a program to SMEs in export certification as an Asynchronous Learning Network. By establishing a mechanism for students in different places to become acquainted with one another and interact, it can generate learning, technology transfer, and trade opportunities.

- Among the projects funded by the **Danish** National Centre for Technology Supported Learning (CTU) is a Virtual Environmental Diploma School. Eleven individual technical and commercial colleges formed a collaborative to teach general environment and work environment practices to public and private organizations and stimulate innovation by using distance learning. Administered by Århus Business College, the computer-based instruction allows enough flexibility to reach companies throughout the regions served by the 11 institutions at any time.

4. Teaching about "soft" technologies

Industries' so-called "soft" technologies (e.g., total quality management, teamwork, and supplier certification) require as much education and training as the "hard" technologies (e.g., equipment and computers). Training is even prevalent in technical colleges than in the hard technologies because they require little capital investment by both schools and customer businesses and thus demand is higher among SMEs. A significant number of colleges are developing the specialized (and certified) expertise in such topics as ISO 9000 certification and total quality management to offer it at a reasonable cost to the smaller firms that are unable to afford private consultants. Other colleges work in cooperation with or employ consultants, all with the aim of accelerating process improvements in local companies.

- Working with the Robert Bosch Corporation and a network of four potential suppliers, Trident Technical College in Charleston, South Carolina, **US**, created a supplier assessment tool that measures five aspects of a small and medium sized manufacturer's operations—from

quality to management—and educates them on changes necessary to meet large companies' rigorous standards and become suppliers. The tool has been adopted by the manufacturing extension partnership programs of many southern states for assessing the needs of SMEs, training their employees, and measuring improvements.

- Milton Keynes College in the **UK**, through its participation in the Milton Keynes Economic Partnership, discovered how tightly the region's growth was linked to, and limited by, transportation and distribution capacities. Many of its companies are links in supply chains and depend on getting products to customers and from suppliers quickly. In response, the college proposed and created, in cooperation with industry, the Chamber of Commerce, and the Training and Enterprise Council, a national centre of excellence in logistics and distribution to provide training in logistics to business that was previously unavailable.[31]

5. Educating managers

Most technical colleges augment their education and training with management education as a way to convert the techniques that their graduates are acquiring into better industrial practices. A 1991 report by the European Union's Industrial Research and Development Advisory Committee recommended for schools "training in management of technological change....to instill managers with innovation and technology management."[32] Management education creates and cements relationships between the college and local employers and the classes and seminars help faculty remain abreast of current business issues and methods.

- When it became evident that local SMEs (many of them defense contractors) needed and wanted management education but were not willing to enroll their employees in regular college programs, Okaloosa-Walton Community College in Florida (**US**) created the Total Quality Institute (TQI). The TQI provides contract management training, drawing on a data base of consultants as instructors in supplement the college staff.

6. Retraining displaced workers

Technical colleges assume various degrees of responsibility for retraining workers displaced by technology, plant closings, or downsizing. The costs are generally born by training or economic development programs, such as the Jobs Training Partnership Act or Trade Adjustment Assistance Act in the U.S. or the Adapt program of the Social Fund in Europe, but the colleges conduct the training. Since many displaced workers are older and have less formal education than typical college's entering students and often have had little experience with new technology, the initial basic education and literacy components are often quite high.

- A series of specialized courses in Job Seeking Skills and basic Computer Skills were run by Institute of Technology - Tallaght in **Ireland** for 101 redundant Packard employees during August/September 1996. The Institute contacted 869 former Packard workers which resulted in three courses organized to suit needs of applicants—a Job Skills Course, Introduction to Computers, and Follow-up to the Summer Computer Course. Participants commented on

the benefits of the training. For example, some participants expressed a keen interest to pursue qualifications to enable them to be employed in the computer industry, but most believe that Information Technology is now a life skill and important in terms of confidence and information in applying for any job.

C. Technology Intermediary: Accelerating Diffusion

A less common but growing role for technical colleges is that of regional technology intermediary. The technical college that can successfully remain abreast of technological changes becomes a pre-eminent storehouse, transmitter, and gatekeeper of technical knowledge. The experience, know-how, and entrepreneurship of the faculty, accumulated technical information of the school, and access to the technologies owned have potential added value to local companies. In these situations, college faculty serve as change agents and advisors for industry, helping firms to assess their operations and develop and implement plans, and ensure that the work force has the requisite skills.

1. Technology centers

A decade ago the dream of many a technical college was to build and operate a state-of-the-art computer-integrated manufacturing (CIM) center, or, if financially unattainable, at least a flexible manufacturing cell. These centers were expected to prepare students for, and demonstrate the value to, SMEs of the latest advances in process technologies and management techniques. In some places the facilities were called "teaching factories," in others "advanced manufacturing centers." The school-based simulated manufacturing systems enable both students in non-apprenticeship programs and companies' employees to learn on new technologies in life-like production environments.

Technical colleges (that are not restricted from industry using their facilities) also rent technology downtime to local companies for process research, product development, or start-up training. In some countries (the U.S. and Germany), this has stimulated public-private partnerships between colleges and equipment manufacturers that have been willing to loan or donate their products to the colleges. For example, in the United States, IBM, AutoDesk, and others gave millions of dollars of equipment and software to colleges and organized alliances of schools using their systems. While these centers have been moderately successful, student demand more often than not has been insufficient to justify the costs of maintenance and upgrades, and many centers have partially dismantled the integrated centers to maximize use of the individual components. Newer centers have turned more to the information technologies and used computers to simulate elements of the CIM center.

- The Aachen Demonstration Laboratory for Integrated Production Technology (ADITEC) in **Germany** is non-profit teaching factory for training and retraining technical and other workers located at the Technical University, RWTH. It was conceived in 1992 by faculty who discovered that the "university was not the right environment for companies." ADITEC targets skill upgrading of engineers and technicians through short seminars (1-2 days),

workshops (2-4 days) and long-term training (which it would like to expand). The university provides the overhead and rents them the building. University and consultants also rent back some of the space in the facility.

- Last year De Anza Community College in Cupertino, California, **US,** opened a new 66,000-square foot Advanced Technology Center (ATC), which may represent the next stage of advanced technology centers. It focuses on computer technologies that can be applied to a broad set of workplaces including but extending beyond manufacturing. The new ATC facility, wired for 1,200 computer work stations, already has nearly 600 in operation. In addition, companies (e.g., Sun Microsystems and Silicon Graphics) periodically send employees to the ATC for workshops to learn about new industry trends.

- Moraine Valley Community College in Illinois, **US** created a Center for Contemporary Technology to emulate the manufacturing environment in 1988 as a response to the loss of the region's manufacturing base. About the same time AutoDesk, the leading producer of computer-aided design (CAD) software, was building a network of training centers at technical colleges. It selected Moraine as an AutoCAD Training Center that could keep the college on the leading edge of the technology, endow the education programs with continuous improvement, and transfer technology (AutoDesk's) to industry. The Center targets three audiences: industries that use CAD, credit degree and certificate students, and firms that want to update software. The Center is expected to operate as a business and meet quality control standards and client expectations.[33]

2. Technical assistance and advice

Staff at technical colleges with industry experience and expertise who build relationships with local companies become valued sources of information for the businesses and, in effect, consultants and advisors on problems. Some of this interaction is informal, occurring through a phone call or in conversation at a meeting. In other instances, staff are allowed a certain amount of release time for advising and even paid consultancies in the belief that involvement in real industry problems enhances their value as teachers. Further, students often have an opportunity to work on actual industry projects. For example, Alabama's seven Bevill Centers, each part of a different community college in the state, form the core of the state's manufacturing extension service, the Alabama Technology Network, and faculty both teach and consult.

- In Baden-Wurttemberg, **Germany**, the well-known Steinbeis Foundation places technology consultancies, operated by faculty and students, in all 16 of the region's fachhochshulen. SMEs get the benefit of the expertise in the college and students and faculty gain experience with real industry problems and new technologies. These centers, which are demand driven and must become self-sufficient. Throughout the region, Steinbeis has more than 200 technology transfer center, and some of the sector-based centers also are at fachhochshulen—for example, a medical technology center at Fachhochschule Ulm and a process engineering and biotechnology center at Fachhochschule Mannheim.

- The Northwest Wisconsin, **US** Manufacturing Outreach Center is a partnership between the University of Wisconsin-Stout and five of the state's 16 technical colleges to serve the 3,000 manufacturers in this region of the state. Each college has a district coordinator who develops and executes technical assistance and training projects that include assessments, problem identification, and impact analysis. The project is funded partly by the national manufacturing extension partnership (half) and state and local funds. Companies are also expected to pay fees for work beyond the initial stages.[34]

3. Industry cluster or sector hubs

Some technical colleges aspire to become the core location where SMEs can congregate and acquire specialized education and training, information, and services. Such hubs allow SMEs to scan information about new developments in markets, techniques, and technologies. To develop this level of expertise requires a high level of specialization and concentration of resources, expertise, and knowledge, a choice that only some colleges are willing to make. Most exist in the presence of a significant cluster and strong industry leadership and support and focus on some circumscribed subset of a region's businesses based on similarity of processes, interests, and needs. More often than not, this level of specialization and industry acceptance is industry rather than college driven.

- In Catawba Valley of North Carolina, the hub of the **US** hosiery industry, the community college, in cooperation with an industry association, formed a hosiery technology center. Equipped with machines from the oldest to the latest computer-aided Lonati knitting machines, the center trains repair technicians, knitters, and managers and is developing training programs for dyers. The SMEs rely on this center not only for education and training, but information about technologies, markets, and the latest research. The college center recently organized a network of local companies who jointly invested in an R&D project with North Carolina State University to develop automated boarding equipment.

- In Wales, the **UK**'s Carmathenshire College established a bureau for the local woolen mills to introduce and train workers to use computer aided design. It gives students experience in industry and helps SMEs modernize. This program received funding under EUROTECNET as an innovation because of the way it networked expertise and experience with curriculum development to aid local industry.

4. Hosting technology services

To take advantage of relationships between SMEs and technical colleges, some other agencies that deliver services to SMEs, such as technology deployment offices, R&D centers, and small business assistance centers, find advantage in locating offices at the colleges. Some technical college staff work or hand-in-hand with university or state extension services that may be actually housed at the college. In the United States, for example, Illinois and North Carolina have placed and supported small business development centers in the community colleges and

Alabama has established its technology extension program in centers that are partnerships with seven technical colleges. While these agencies gain access to SMEs by virtue of their association with the college, the college benefits by exposing faculty and students to real industry problems and, frequently involving faculty and students in projects as consultants or interns.

- In **Ireland,** Forbairt, the national agency responsible for science and innovation, has established industry-based technology centers at most of the Institutes of Technology, the most recent being a Furniture Technology Centre at Galway Mayo Institute of Technology in Letterfrack. Located at a college, faculty, often with dual responsibility, are able to take part in the R&D and students work on real projects. Others Centres include the Nautical Enterprise Center at Cork Institute of Technology, the CAD Centre at Waterford Institute of Technology, and the Toolmaking Industry Research and Advisory Centre at Sligo Institute of Technology.

- Hagerstown Junior College's Advanced Technology Center in the **US**, which specializes in microprocessing, computer integrated manufacturing, electronics, photonics, and robotics, hosts (1) an office of Maryland's manufacturing extension service, (2) a small business development center, (3) the state's regional technology council, and (4) the offices of a four-county economic development agency. The central location of these linked resources encourages more complementary and collaborative approaches to regional development.

5. Operating new business incubators

Some of the business incubators, which became so popular in the mid-1980s, are situated at technical colleges. This keeps them near sources of training and technical assistance and provides an easier transition for entrepreneur-minded graduates into the marketplace. These incubators are often formed as alliances of colleges with economic development and technology agencies or small business development centers, which complement the services of the college.

- Chattanooga State Technical College in Tennessee (**US**) co-sponsors a 1,225 square foot new business incubator in cooperation with the Chattanooga/Hamilton County Business Development Center. The college's small business development center is located on site and provides for the business tenants management, two small business counselors, 75 volunteers from business, a computer laboratory, a resource library and video center, and regular training courses and seminars. At the close of 1997, 70 businesses employing 391 people occupied the incubator—11 in manufacturing, 24 owned by women and 7 by racial minorities. Over the life of the incubator, 175 businesses employing 1,500 people have graduated and 85 percent are still in business.

- The Dublin Science Technology and Innovation Centre is scheduled to be opened in 1999 at the Citywest Business Campus in County Dublin, **Ireland** at the epicentre of a number of major technology sites as well as a host of second tier high technology industries. The Centre will offer shared communications technology, management skills, marketing resources,

product development and venture capital to about 30 start-up companies. The government has a 71 per cent share in the centre, contributing £2 million towards its development with £500,000 from private investors in technology industries. It is being established in partnership with Dublin's third-level institutions, South Dublin Chamber of Commerce, Citywest, the Department of Enterprise, Trade and Employment and state industrial development agencies. The key difference from other incubation sites will be a focus on information and biomedical technologies and the provision of comprehensive management supports, including access to venture capital and international marketing resources.

D. Fomenting strategic alliances: Learning companies and learning communities

As part of regional production systems, technical colleges are not independent or autonomous institutions. Most acknowledge the interdependencies and, accordingly, plan and coordinate programs with other agencies, businesses, and schools. A survey of 173 such colleges in the U.S. by the American Association of Community Colleges in 1978 revealed more than 10,000 cooperative arrangements. Further Education colleges in Great Britain work closely with 82 Training and Enterprise Councils in England and Wales and 22 Local Enterprise Companies in Scotland, which were created in 1990 and made responsible for youth training, employment training, SME consultancies, work related further education. Since 1995, the TECs have administered a Further Education Competitiveness and Development Fund to allow the colleges to be more responsive to local labor market, employers, and individuals.

It is not the fact of cooperation that makes the alliances innovative; it is the *nature* and *scope* of the relationships. They are (1) more formal and reciprocal agreements among the member organizations and businesses, (2) more clearly defined expectations for economic development and roles, (3) a much broader set of partners than ever before, (4) long-term strategies and, perhaps most important, (5) alliances not with individual customers but with business associations. The alliances are not formed simply to carry out a project or take advantage of a funding opportunities.

This may be one of the more important trends among technical colleges, indicative of a change in from competition and turfism to cooperation and alliances. Many are incorporated and have boards of directors and by-laws defining relationships and responsibilities. Some of these entities only plan, coordinate, or broker activities while others deliver real services. Some alliances are targeted to specific industries and others are more generic. Partners include other colleges, universities, cities, economic development modernization agencies, *and* business associations. Examples drawn from four case studies described in Section V are shown in Table 5.

Table 5
Typical Relationships at Four Colleges

College	Partner	Form of Partnership

EUC-Syd (DK)	ITAI (local technology center) Regional Development Council Danish National Centre for Distance Learning AMU (adult education & training center) Trans-Atlantic Technology and Training Alliance	Project based coop. Informal association Project cooperation Articulation Formal association
DeAnza Community College (US)	Manix (technology extension program) NOVA (employment & training programs) Work Force Silicon Valley	Competitive tension Strong cooperation Strong alliance
Galway-Mayo Inst. of Tech. (IR)	Connemara West Development Agency Forbairt - Science & Technology FÁS - Employment & training Trans-Atlantic Technology and Training Alliance	Strong partnership Strong, co-location Moderate association Formal association
Itawamba Community College (US)	Mississippi State University extension service Appalachian Regional Commission Jobs Training Partnership Act Community Development Foundation High school vocational centers Trans-Atlantic Technology and Training Alliance	Weak articulation,coop Financial support Strong, co-location Strong cooperation Articulation agreements Formal association

Note: *Partnership* implies formal agreement; *alliance*, formal working arrangements; *cooperation*, formal alliances on special projects or in particular situations; *association*, informal alliances on special projects or in particular situations.

1. Forming alliances with industry

Modernizing businesses that purchase training as well as other related services from the colleges also often enter into formal working agreements with colleges. In the U.S., business managers frequently serve on advisory boards and are becoming active in new school-to-work transition programs. Europe Commission programs such as COMETT encouraged colleges to form alliances across national boundaries. And colleges, in general, have close ties with business associations.

- In the northwestern panhandle of Florida in the **US,** Okaloosa-Walton Community College formed an alliance with 31 companies that call themselves the Technology Coast Manufacturing & Engineering Network (TeCMEN). The alliance also includes Gulf Power Corporation, the county's economic development agency, and nearby federal laboratories. Incubated and still headquartered at the college, members share training programs, do joint marketing and product development, and bid on contracts together. As a result of the network activities over the first five years, member firms added 400 new jobs.

- **Austria's** vocational system, like many European nations, is under the control of its social partners. For many years, the apprenticeship program has been operated by the chambers of commerce while higher education remained in educational institutions. In 1995, Austria formed a unique virtual Fachholchschulen, allowing a wide range of institutions and organizations to offer Fachholchschulen courses for credit. Any body wishing to offer a course submits it to the Fachholchschulrat for accreditation. Among those now able to offer credit education are the nation's WIFIs, the training arms of the Chamber of Commerce.[35]

2. Forming consortia with other colleges

Colleges are also discovering the value of creating their own consortia to take advantage of each others' strengths, to tackle common problems, and to achieve economies of scale. EU programs such as COMETT have encouraged these consortia, but even in non-EU countries, alliances are becoming commonplace.

- In the adjacent states of South Carolina and Georgia, five technical colleges, the **US** Department of Energy, and industry jointly formed the Georgia Carolina Technical College Consortium, Inc. Members expect to build a common resource and training center. By pooling resources, faculty and programs, the consortium attempts to coordinate, improve, and expand the training of students, faculty, and workers, as well as become a clearinghouse for applied research.

- In Glasgow, **Scotland**, Anniesland and four other further education colleges in the city have formed a community college group and recently employed a full-time officer. These five colleges on the periphery of the city serve their communities largely with non-advanced further education. The alliance helps colleges more effectively lobby, share European programme funds, and contribute to national and local initiatives that address the city's structural unemployment. Together they pool staff development, purchase insurance and common supplies, and map curriculum to increase the efficiency of constituent members.

3. Cooperating with technology and economic development agencies

Relationships with economic development agencies are growing as the quality and quantity of the work force proves essential success factors in their work. Colleges are often highlighted in their marketing and included in most state or regional planning efforts for technology or economic development. It is common for development agencies to bring potential business investors to the colleges, and most inward investment trips abroad include technical college administrators. For example, U.S. and Irish colleges have industrial liaison officials who work closely with development offices in planning continuing education and customized training. Relationships with technology intermediaries also are increasingly common, particularly as modernization and training become more interdependent. These alliances, like many of the most successful corporate consortia, are not simply two-way relationships; they are complex relationships, involving multiple members, with the colleges taking on the role of "system integrator." The Oklahoma example also includes the Oklahoma Alliance for Manufacturing Excellence, the state's extension service; the Wales example includes the Welsh Development Agency; and the Michigan example includes the Midwest Manufacturing Technology Center.

- De Anza Community College's Center for Applies Competitive Technologies (CACT), for example, emulates the networking of industry in the **US**' Silicon Valley, forming affiliations, networks, and alliances. The Center has a formal affiliation with the NASA Regional Technology Transfer Centers, the University of Southern California's technology transfer center, and the Electronic Manufacturing Productivity Center in Indianapolis, Indiana; a

"memo of understanding" with Lawrence Livermore National Labs; and a cooperative agreement with Sandia National Labs.

4. Facilitating intra-firm learning and technology diffusion

The learning company has become a prominent goal of industrial policy in all OECD countries, but most analyses of technology diffusion eventually come to the conclusion that businesses learn best from each other. The rapid and informal diffusion of ideas and information through social channels is considered a major factor in the success of many of the world's most competitive regions such as Silicon Valley in the U.S. and Emilia-Romagna in Italy. These are exceptions, however. SMEs in most places lack the formal and informal infrastructure to support learning. Therefore, some technical colleges have taken on the task of creating a structure to accelerate learning.

- Institute of Technology Tallaght in Dublin, **Ireland** participates in the successful PLATO program where parent companies support and advise networks of 10-12 smaller companies in a region. Three of the colleges' lecturers are group leaders in the monthly meetings of the PLATO networks and other staff members take on consultancies for the firms.

- Grand Rapids Community College in Michigan, **US** manages Continuous Improvement User Groups (CIUGs), which include 6 to 12 SMEs and are intended to encourage finding solutions to common problems, exchange of information and innovation. The CIUGs meet regularly, rotating from company to company and college staff facilitate the process of SMEs helping each other with production and management problems.

V. Four Cases in Point: College/Cluster Connections and Technology

According to a recent OECD report, "There is widespread agreement that the development of an appropriately skilled and adaptable work force is a crucial element of an endogenous strategy for regional development and the competitiveness of regions. It is not the supply of skills *per se* that is the key element, but rather the mix of skills and competencies, which must fit the region's economic profile and development needs."[36]

In many regions, the industrial profiles have very distinctive peaks that define concentrations of similar or related businesses ("clusters"). This has led to new approaches to analyzing economies, scanning for clusters and using the profile to formulate policy and deliver services. In some places, technical colleges have adjusted to and focused on the needs of those clusters that fuel their economies. For example, in New Zealand, Nelson Polytechnic has a special school for seafood technologies and Christchurch Polytechnic concentrates on electronics. Portugal established CENCAL, a Vocational Training Centre for the Ceramic Industry in in Caldas da Rainha, the hub of porcelain, pottery, and stoneware manufacturing. In the United States, Pennsylvania's Northampton Community College has a special center for electrotechnologies and California's Santa Monica Community College is building a center for animation and multi-media.

In Scotland, Ayr Technical College has a new set of programs for its growing electronics industry. In Denmark, Roskilde Technical College specializes in meat processing technology and in metalworking at Metalindustriens Fagskole. And in the UK (Wales), Barry College has a special center for aircraft maintenance.

Technical colleges that target clusters endow their regions with economic advantages. By grounding the skills and knowledge acquired by students and the services offered by the college in the milieu and real problems of the industries, businesses are able to realize increased productivity and profitability. Businesses get appropriately skilled labor pools, assistance with retraining, technical assistance, and perhaps special technology services and information.

Clusters also imbue technical colleges with certain opportunities. First, education is more effective when rooted in experience, and a local cluster creates a real life context for learning and is likely to be relevant to the lives of many students. Second, informal learning and skills that are not easily verbalized or codified are enhanced in environments where students have closer contact with the work place and work force, and where work is a common topic of conversation ("schmoozing"). Third, labor markets function more effectively in clusters where news of job or economic opportunities can spread quickly to students through social networks. Fourth, colleges that choose to concentrate resources on a cluster are more apt to become a true center of excellence with industry specific expertise, knowledge, and technologies.

Much can be learned from technical colleges that adjust and specialize to respond to the changing technologies of the clusters by examining their credit and non-credit education and training programs, the operations of their technology centers and advisory services, and the value and impacts of their social partnerships and links to the community. Recent case studies of technical colleges in four clusters illustrate the process and possibilities.

A. College/Cluster Connections

The four clusters on which the following section is based[4] are furniture in northern Ireland and northeastern Mississippi and electronics in southern Denmark and California's Silicon Valley. In each place a community or technical college has forged a special relationship with the regional industry cluster and established itself as a key player within the cluster. Each of the cluster-specific programs developed its special focus for a somewhat different reason. The two furniture programs were *supply side interventions* to deploy and diffuse new technologies. The two electronics programs were *demand side responses* to a high-growth, rapidly changing technology-based cluster

- Ireland's furniture industry—about 600 companies employing 5,000 people—is dispersed over the largest area of the four and has the weakest links among firms and specialized

[4] Based on research conducted by this writer for the Community Collkege Research Center at Teachers College, Columbia University, New York, New York in 1997.

services. Yet the cluster is important to Ireland and earmarked for further development and growth because it is indigenous—in contrast to the large number of foreign companies attracted to Ireland over the past decade. The college was started as a rural development policy to stimulate youth employment but ultimately justified as an technology policy to revitalize the furniture cluster.

- The northeastern region of Mississippi is home to 20,000 people employed by 183 furniture manufacturers and 153 suppliers, supported by an array of specialized services including factor houses, trucking companies, and training programs, producing mid-range, mostly upholstered, furniture for mass markets. In establishing the Automated Furniture Tehnology Center, the college's aim was to be a catalyst for adoption of more advanced techniques in what had been a low-tech industry now threatened by foreign competition. The Center also was supported by automated equipment manufacturers seeking greater market penetration.

- California's Silicon Valley is the nation's quintessential and widely acknowledged benchmark cluster. With scale, specialized expertise, experienced workers, social capital and networking, and entrepreneurial energy, it virtually defines the term "cluster." Silicon Valley has 6,000 plus companies in a 50-mile corridor; a strong army of suppliers; capital equipment companies; and exporters. The colleges' programs were driven by large companies forming partnerships with them, to ensure a continuing stream of skilled and re-skilled workers in this intense, dense technopole. Technology programs were to take advantage of federal funding opportunities for technology deployment to SMEs.

- The southern part of Jutland in Denmark is home to more than thirty companies in the electronics sector and another dozen developing related software. Since Denmark is an expensive place to do business, the cluster's advantages are its human resources—skills, knowledge, innovation, and entrepreneurship. The cluster has managed not just to survive, but also to thrive in this region because of its wits, accumulated wisdom, and innovations. Its growth depends heavily on strong educational institutions such as EUC-Syd.

Table 6
Catalysts for Cluster-Specific Programs and Reasons

EUC-Syd	National mandate to specialize (economies of scale) and industry concentration (employer demand)
De Anza CC	Federal funding opportunities (technology diffusion) and equipment manufacturers (market penetration)
Mission CC	Semiconductor industry (employment needs) and leadership priority (industry focus)
Galway-Mayo Inst. of Tech.	Community development centre (local development and youth employment)
Itawamba	Community development foundation (economic development) and equipment manufacturers (market penetration)

In programs connected to specific clusters, most students are either employed in the industry part-time, or are in programs that demand or encourage apprenticeships or other worksite experiences, and have a relatively easy time finding work placements. In all four sites combined, about three in five students have or have had work experience in their respective sectors.

Continuing education, including evening short courses, for firms in the clusters is a major growth area for all five colleges in the four clusters, generating revenue, imparting new skills to the companies' employees who participate, and creating opportunities for networking and informal learning. At EUC-Syd and Itawamba, continuing education courses award college credits, but at the other three sites they are non-credit. Large companies that can afford to fill classes and pay costs typically dominate the programs at most colleges. SMEs, who usually share classes, have to compromise to meet their common needs.

B. Impacts on students

Evidence from surveys and interviews of employers and educators suggests certain advantages from connections. Job offers at high wages relative to surrounding regions are plentiful, and informal labor market information networks make traditional college placement services superfluous. With education tailored to the work of the industries and with students well prepared for jobs in the clusters, employers interviewed expressed high levels of satisfaction with graduates.

Most concerns were with quantity, not quality. In the U.S. sites, a strong economy actually inhibits both enrollment and completion. Labor shortages, particularly in the Silicon Valley, lead employers to try to hire students before they finish. Large companies encourage new hires to return, and even reimburse them for the costs, but many SME employers entice promising students into jobs as soon as they acquire the minimal critical skills needed. Europe also faces labor shortages, but in Europe, the postsecondary, pre-baccalaureate credentials have greater acceptance by and value to industry than in the U.S.

European colleges place a greater emphasis on the final skills certification process, which keeps students in school until they graduate. The main reasons for dropping out of programs in the U.S. sites, where entrants are older, is lack of seriousness about career paths or confidence that they can get the job they want. In Europe where enrollment is generally a continuation of a youth's educational process, students are more apt to drop out due to poor academic performance.

In Mississippi, demand for skilled technicians depends largely on the rate at which industry adopts new technologies. Currently, only the largest companies are modernizing. Since graduates' skills and knowledge are transferable to many other sectors, if local companies fail to create opportunities, the cluster may lose some of its best and brightest technicians and future owners. In Ireland, students are forced to create demand for their skills since so few firms are prepared for their talents.

Students operate in a sellers' market in California's robust electronics cluster. In this rapid growth economy, employers compete and recruit from each other to obtain qualified and experienced workers. Most students in electronics or computer systems have a wide choice of jobs. But the growth culture of the region creates high expectations, and employers are challenged to meet them. The cluster is characterized by highly fluid labor markets, job mobility, and little tradition of firm loyalty. In Denmark, students are wary of the electronics cluster's future, in part because of its dependency on one large employer. There still is sufficient demand—and is outpacing current supply—but students are watching the market carefully.

C. Advantage to clusters and impacts on technological change

Business leaders and economic development officials alike are quick to acknowledge the advantage and importance of having a sizable pool of workers skilled in and knowledgeable about the cluster. Executives may talk about wanting employees with basic skills and ability to learn but, in their hiring practices, managers still prefer a solid base of industry-relevant experience. The college also adds advantage by contributing to the region's social infrastructure through its continuing education, industry seminars, and other events, which provide safe havens in which businesses can mingle freely, get to know each other, build trust, and learn from one another.

In Mississippi, the automated center gives employers an opportunity to pilot new equipment and train their employees. Graduates of Itawamba Community College's Furniture Technology Program are well positioned to become catalysts for change within an industry cluster that has been a slow and sometimes reluctant adopter of new technology. But in hiring, experience seems to be more important than formal education credentials to Mississippi's mostly self-made furniture industry cluster. Many of the cluster's owners came through the ranks of industry, not through the educational system, and skills are more important to them than degrees.

In Denmark, which has a comprehensive technology infrastructure, and where what a college can and cannot do is more tightly regulated, the college concentrates more on its primary mission of education and training. But the educational process, which includes a large workplace component, is in itself a joint venture with industry. Participating businesses, many of which are managed or owned by alumni of the school, maintain very close ties to the college and realize and appreciate the value of the pool of highly skilled technicians that the school produces. The college's apprenticeship program is a form of interdependence, creating bonds between college staff and industry management.

Ireland's Furniture College will require some time to build productive links with industry—largely because the cluster lacks the social fabric to collectively develop a common sense of purpose and vision. Firms are not organized to take advantage of opportunities to cooperate that might build comparative advantage. The new Furniture Technology Center and the young skilled workers and artisans it produces are intended to change that. How quickly the industry accepts and uses the resources of this College and Center will be a test of their

effectiveness. Currently the number of graduates is too small to have a discernible impact, but with the expansion of the program, certificates, diplomas, and B.S. degrees quadrupling by the end of the millennium, and if the new technology center can connect with and catalyze enough companies, that ought to change.

In California, because employers have many avenues to see and learn about technology, e.g., universities, trade shows, and neighboring firms, they are less likely to learn about advances from community colleges. But as the workplace requires greater depth of scientific and general knowledge, public community colleges become more attractive to businesses than the more narrowly focused, private, technical schools. Community colleges also are major sources of management training and technical assistance in emerging issues such as quality and environmental regulations for the smaller companies that are less able to afford the numerous consultants in the area. Non-credit college-based programs such as De Anza Community College's Center for Applied Competitive Technologies or the Small Business Development Centers provides such low-cost expertise and services.

D. Advantages to regional economies

The impacts of cluster/college connections on their respective regions take three forms. First and foremost, the colleges contribute to synergy. As a result of the mobility of their gradutes and and their contributions to the flow of information among firms, their impacts on the region are greater than the sum of their individual impacts on their customers. Second, the school as an institution is a major local employer, a growth industry that is itself a source of local revenue, and a magnet for community and cultural events. It keeps youth in the area and all their associated income. Third, the college is marketed in industrial recruitment, and is often an important consideration of businesses choosing among alternative locations. In the U.S., college staff often accompany recruiters on trips and the college is a regular stop for visiting site selection teams.

In Denmark, EUC-Syd college is acknowledged by local development authorities as one of the region's major strengths. It is the engine that generates much of the region's skills, knowledge, and innovation that gives the region sufficient competitive advantage to offset the high costs of doing business. According to the director of the Regional Development Council, the region's economic vitality is due largely to the efforts of the technical college and the university. More and more people, however, "want higher education and fewer want semi-skilled and skilled positions." This may mean that the less skilled work will be forced to become skilled or move to other places.

Table 7
Major Benefits to Host Regions

EUC-Syd	Highly skilled labor force key to growth and retention Magnet for and locus of recreational cultural activities
De Anza and Mission CCs	Work force development and retraining Curriculum development and education for/with large employers

	Industrial retention
Galway MIT at Letterfrack	Significant employer and source of local wealth Led to improvements in infrastructure to accommodate students
Itawamba CC	Source of information about new technology Industrial recruitment incentive Catalyst for modernization, aggregate impacts on industry

In western Ireland, the effects on the local economy are mainly derived from the college as an enterprise rather than the students it produces. All but one of the students surveyed expect to leave the immediate area—not surprising since there are few local companies able to employ them, and because young people often seek a more urban environment with more social amenities. Nevertheless there are already obvious immediate effects on the community. For example, as a result of the college, there is regularly scheduled bus service to Galway, new sports events, music, recreational activities, more reason for young people to remain in this area (which had been losing 70 percent of youth on average each year), housing improvements to accommodate the growing student body, new full-time and part-time teaching and administrative jobs at the college and service jobs to cater to the student body, and increased sense of security for isolated elderly people who rent to students. The real test, however, will be whether some students later choose to return to the area as entrepreneurs. The new furniture technology center, as it develops, may create even more opportunities for new businesses in the Connemara region. In winter 1998, the college and technology center are planning to open a branch of a furniture company in Letterfrack.

Mississippi's northeastern regional economy, which features a furniture cluster, is well outperforming the rest of the state. Furniture manufacturing led the region out of dependency on agriculture into an industrial age, but at a time when there was little international competition and a vocational high school education was sufficient to enter the semi-skilled labor force. Now that industry leaders have begun to modernize, a high school diploma and hand labor are no longer enough, and companies are looking increasingly to the community college for higher level of skills as well as information, retraining, and assistance. There are few locally available alternative sources of training for industry.

In California, workforce issues have become the greatest barrier to the region's growth and thus among the highest priorities. The Santa Clara Valley Manufacturers' Group named as the most three critical issues facing the region: housing, transportation, and workforce development. "Employers report it is difficult finding applicants [electronic and electronic engineering technicians] who are both fully qualified and experienced as well as qualified but inexperienced."[37] Without a specialized labor force, the cluster would exist but lose much of its luster and diminish the advantage of the region in retaining local production. However, in this well-endowed region, the contributions of the two colleges to electronics industry are somewhat fungible with the many other public or private institutions. Although each college has tried to distinguish itself from other schools, and to some degree each has, the true advantage of the region

is the sum total of its education and training establishment, of which De Anza and Mission are two large components.

E. Summary effects of cluster connections

After studying five colleges in four locations, what has been learned about the proposition set out at the start that "college/cluster connections can enhance the competitive advantages of clusters and improve opportunities of individuals through more effective acquisition of codified and tacit knowledge and more efficient labor markets and economic development?"

Educational effects: The codified knowledge imparted through a formal educational process that is grounded in a workplace context reflecting the specialized nature of the industry enhances learning. It gives students the chance to apply the theory they learn in school to problems that they may face on the job, which, according to employers, significantly adds to their value. According to students interviewed, it also enhances their education. Tacit knowledge is acquired through the work experiences and exposure to other workers while in school, through team projects and social circles that include other. Exposure to real work situations, specialized environments that draw students together into social situations, and company exchanges facilitated in evening courses that enroll employees from different companies create opportunities for informal learning. Labor markets work well in clusters, and placement offices are rarely needed or used by students. Most learn about available jobs from their teachers, part-time employers, other students, or friends. There are, however, unintended negative consequences of good information. In the U.S., students who enroll to acquire skills or find jobs are tempted to drop out before completing their program. Also, employee turnover rates are high as a result of workers learning about more quickly about promising or better paying opportunities elsewhere. Companies in clusters accelerate this by "poaching," or encouraging workers to switch jobs.

Economic effects: Effects on regional economies, according to local development officials and employers, take the three forms mentioned earlier: workforce development, direct employment; and contribution to recruitment. In the cluster, the well-prepared labor pools produced by the schools are the leading locational advantage according to local employers. Other services offered by the schools reach and affect smaller numbers of businesses over time, and fill important niches, but the full economic impact on smaller employers is less obvious to development agencies seeking large scale and immediate outcomes. The schools themselves are large employers, but only in Letterfrack does it dominate the local economy. Industry cluster connections bolster inward investment efforts if their skill and service requirements match those of the cluster. College/cluster connections in the four places studied do exist, influence curricula, attract resources, and benefit the clusters. Although the colleges in the clusters offer a wide range of occupational programs to meet diversified economic and student interests, they but pay special attention to the cluster, particularly through specialized services.

VI. Issues and Obstacles

Although many technical colleges are aggressively pursuing opportunities to accelerate technology diffusion and economic development, many are still operating in a very traditional mode, and the colleges that have been cited as exemplary are, in many ways, still atypical. For every entrepreneurial action there is a reaction, every innovation, resistance. It is perhaps inevitable that changes in the structure of work, advances in technology, and alterations to the scope and mission of technical colleges create tensions and threats as well as rewards and opportunities. For example, are the pragmatic ends of technology based economic development consistent with the intellectual purposes of knowledge acquisition? How much emphasis should colleges place on pre-baccalaureate technical education and how much on higher education? Can academic rigor be balanced with open enrollment policies? Should colleges attempt to keep their schools stocked with the latest technologies? How can colleges help fill the pipeline of technically competent workers needed by business? Are colleges able to compete with industry's pay scales to hire and keep teachers with experience? Following are some of the issues to be resolved if the technical demands of regional economies are to be met.

Threats to image and prestige of institution.

Many technical colleges aspire to "upgrade" their programs by offering and awarding higher levels degrees in the belief that becoming more like universities will improve their prestige and access to resources. Third level colleges wish to become polytechnics and polytechnics wish to offer post-graduate degrees. Two of New Zealand's polytechnics have been considering becoming universities and in February 1998, Ireland's regional technical college were renamed "Institutes of Technology," hoping to increase enrollments in B.S. programs. When the UK's polytechnic's choose to reinvent themselves as universities, it left a skills gap that led to the formation of Further Education colleges. If these schools continue to value the pre-baccalaureate technical degree and maintain an emphasis on serving SMEs, the upgrade could strengthen their position in the community and add to their value. But if the upgrade shifts emphasis away from technicians, where demand is high, and away from local industry problems to higher level, more publishable research, the regional economy may suffer. In an era when employers are claiming that shortages of technicians are a greater problem than shortages of engineers, this seems somewhat of an incongruity.

Threats to image and prestige of individual.

Skill shortages are fast becoming the biggest threat to growth in technology-based industry, leading to (a) colleges accepting lower ability youth; (b) recruitment incentives for qualified employees; (c) poaching by businesses from each other; and (d) downsizing and outsourcing to places that have labor surpluses. Many OECD countries are facing a spiraling downward trend in enrollments in technical education. This is commonly attributed to parents encouraging their children into academic tracks, influenced both by the perceived higher status and earning potential of "more" education. Manufacturing employment is considered blue collar and has a lower status among youth than service occupations, even if the wages are much better. To maintain enrollment levels in technical programs, lower ability students are being accepted. Even nations

with high unemployment rates are beginning to experience skill shortages. Lack of communication between industry and the public and changing career preferences of youth create mismatches between labor supply and demand.

Faculty resistance to change

There is no consensus among faculty that colleges ought to have an explicit economic development mission. Many members firmly believe that the fundamental purpose of education is civic, not economic, that colleges help to unfold the students' potential, and that connections to economic outcomes subvert the true purpose and meaning of education. Others resist change because it requires considerable effort on their part to restructure the content, learn how to use an unfamiliar technology, or rethink the teaching process. Still others resent the higher incomes of faculty who are recruited from industry and may supplement their already high salaries with consultancies. In the U.S., some colleges have avoided fully integrating the education and economic development missions by creating what some call the "shadow college," special or semi-autonomous departments or centers that house the non-credit, industry driven programs and can operate with more flexibility than public education allows. But since a supportive faculty is vitally important to a college's level of activity in the regional economy, all of the faculty must be included in the planning processes and nurtured.

The contradiction between employers' rhetoric and actual hiring policies

W. Norton Grubb found that in the U.S., despite the widespread support for competencies such as communication skills, problem solving, and critical thinking, many employers prefer to hire people with industry-specific skills and experience. SMEs that invest little in training, in particular, favor experience and job specific skills while large employers that have internal training and career ladders are more more likely to choose critical thinking and problem solving skills. On balance, Grubb found that "It is usually crucial to have experience in work specifically related to a firm's production process."[38] This does not diminish the importance of the soft competencies, but it does suggest that they are more highly valued by industry when taught in the real context of a particular industry environment and its technologies.

Keeping pace with technology

Many colleges have built scaled-down advanced manufacturing factory environments not only for education and training but also to showcase their capabilities and market themselves to businesses. But some have subsequently discovered that (1) it was difficult and expensive to remain state of the art, and (2) if they could, the technologies were well beyond the current needs and payback requirements of most SMEs. As a result, large number of centers have not met expectations and are still underutilized by SMEs—particularly where they are not demand driven by industry but inspired by educators. Some of the best equipped colleges rely heavily on donations from large customers and equipment manufacturers. Itawamba's Advanced Furniture Technology Center, for instance, is equipped mainly by the Gerber Corporation which installed

its latest equipment for free and regularly upgrades it—with the understanding that the college will demonstrate it to potential Gerber customer-firms and conduct the training necessary for those that use it. Large employers and students make good use of the Center, but small firms are conspicuously absent because the equipment is more advanced and expensive than their needs.

Fragmentation and competition among education and training providers

Technical education and training is itself a business within a highly competitive industry because most revenues are based on class enrollments. Since institutions often have overlapping authority and duplicative program offerings, colleges compete with universities, other technical colleges, for-profit training centers, and consultants. In California's Silicon Valley, for example, eleven different institutions offer pre-baccalaureate education in electronics, nine different agencies or institutions offer programs in computer management information systems and five teach computer repair. In the U.S., government further contributes to the confusion and fragmentation; currently 15 different federal agencies administer 163 education, employment, and training programs.[39] Public institutions often have an inherent advantage over private providers by not having to charge the full overhead rates. But some competition is valuable, as it is in industry, because it spurs innovation and program improvement. Further, colleges often have the advantage of not having to charge the fixed overhead costs that are covered by academic programs. The competitive position of technical colleges is a function of government policy and regulation that determine scope of authority and institutional culture; but ultimately it is a function of entrepreneurial spirit and competency.

Balancing interests of individual with interests of businesses

Adding economic development to the mission has not been without its critics because of the potential for subordinating the interests of students to the profit-making needs of employers. Customized training, in particular, has been viewed as a government subsidy to branch plants. Tensions exist between those who believe that the pragmatic goal of strengthening regional economies undermines the humanistic goal of maximizing individual potential. Balancing programs designed with the best interests of the individual in mind with those designed for the best interests of the region's economy remains a continuing challenge. The European Union's IRDAC warns, for instance, that industrial experience should not be confused with profit-making consultancy but that "consultancy and similar activities should be integrated in explicit, structural and lasting partnerships between academia and business".[40]

Reluctance of SMEs to invest in technology and training

The interest in serving SMEs is often counter-balanced by the reluctance of SMEs to invest in education and training and their inability to employ and profitably use the skilled graduates. This is one reason that the advanced technology centers in the U.S. have been so underutilized. For example, initially De Anza's CACTs followed the typical technology center pattern of setting up computer-integrated manufacturing (CIM) cells to demonstrate and teach advanced methods to

industry. But this center found little demand for the technology among SMEs in the Valley, or even elsewhere in northern California, and it eventually turned to its SME customers to identify their more pressing needs. These turned out to be not cutting-edge technologies, but rather workshops on topics such as environmental or quality requirements, customized training, needs assessments, technology transfer, and technical assistance. Targeting SMEs may require colleges to more aggressively market services and find leading SMEs to catalyze the region.

VII. Public Policy Options

There is no single set of prescriptions for the public sector; each college operates within its unique economic, political, and social system and is both enhanced and constrained by its own geography, history, culture, and traditions. Yet there are some general principles that appear to enhance colleges' ability to respond to and promote technology based economic development. Those principles are (a) encouraging and facilitating alliances with other organizations, (b) nurturing business leadership, (c) brokering business networks, (d) permitting flexible scheduling, (e) allowing and rewarding faculty for staying current with technology in the work place, (f) providing incentives for specialization that matches local needs, (g) educating parents and non-traditional populations about technology career choices, (h) supporting innovation and entrepreneurial activities, and (i) include colleges in regional planning efforts.

Encourage and Facilitate Alliances, Collaboration, and Learning

There are two reasons for encouraging colleges to enter into alliances with other organizations with overlapping missions. First, alliances take advantage of the fact technical colleges place in and connections to the regional production systems and all of the elements function best when interdependencies are made explicit and activated through inter-organizational alliances. Alliances promote learning and sharing of resources and information that leads to more effective practices and programs. The college itself becomes, in effect, the type of learning organization that it instructs it client companies to become, and "practices what it preaches." Collaboration with other colleges, other public sector providers, and private providers reduces costs and rationalizes the region's education and training system for customers.

Nurture Business Leadership

If a region's stock of social capital is low and their business and trade associations inactive, colleges can stimulate creation and accumulation. They do this by establishing forums for business leaders to meet regularly and leading them to to discuss common training and technology needs and address shared problems. Breakfast meetings, management education programs, and technology conferences that target groups with common interests, such as chief executives, human resource managers, women entrepreneurs, or industry clusters all help develop continuing relationships and thus create social capital.

Permit Flexible Scheduling

Many students who work part- or full-time are unable to attend regularly scheduled day-time classes. As a result, in some colleges evening class enrollments far exceed day-time enrollments. At Mission Community College in California's Silicon Valley, 70 percent of the students attend class after 4 PM. A flexible environment in which faculty can schedule (a) a wide range of evening classes, (b) weekend classes, (c) concentrated programs that allow completion in shorter time frames, and (d) classes at remote sites will enable many more youth and adults to upgrade their skills and acquire credentials.

Broker Networks

Business networks around education and training can be an effective tool for reaching small firms. Training networks help small firms overcome isolation, enable them to make costly services affordable, expose them to benchmark operations, and accelerate learning from each other. Most existing relationships between colleges and industry are with individual businesses. But those that have organized potential customer companies into networks make their services more affordable to them, increase their appetite and demand for education and training, and create possibilities for expanding learning among firms. Colleges that are free to enter into, initiate, and broker networks and other forms of interfirm activity strengthen the entire regional production system.

Adopt Learning Technologies

People who are already in the work force and wish to upgrade or acquire new skills may have difficulty reaching a specified place of study at a regular prescribed time. Their work schedules might be uncertain, transportation difficult, or family obligations too demanding. Computer and internet-based technical education and training programs provide flexibility without losing the benefit of classroom interaction and group process. Asynchronous Learning Network ("any place, any time") courses are one mode of education that expands educational opportunities to previously restricted populations.

Allow and reward faculty consultancies

Colleges in which faculty are allowed and encouraged to work with industry (1) personalize college-industry connections, (2) provide opportunities to stay current and new techniques and technologies and (3) add value to the teaching abilities of the faculty member. In some places, faculty already have industry experience but need regular exposure to keep up with changes. In countries with apprenticeship programs faculty are likely to have that opportunity, but where most education is classroom based and faculty have heavy teaching loads special efforts are needed to keep faculty informed and updated.

Incent Specialization and Cluster Targeting

If technical colleges aspire to become true centers of excellence, they must carefully pick their niche and build their reputations through accumulated knowledge and recognized deeds. Since technical colleges are regional, the niches ought to relate to needs of the regions' economy, or one of their major clusters. The more specialized the economy, the easier the choices become, and the most prominent centers of excellence are located in the midst of strong business clusters. A strong cluster, however, is not necessity, and colleges can pick emerging clusters and help them develop. College systems ought to encourage, if not demand, specialization—as the Danish did as part of the educational reforms of 1956.

Educate Parents and Non-traditional Populations about Technical Career Options

In the short term, skill shortages are likely to worsen as the aspirations for higher education increase. This movement toward higher education is fueled by statistics documenting the earnings differentials associated with differences in levels of education. Nations may have to look to populations previously underrepresented in technical occupations for much of their future skilled labor force, such as women and ethnic minorities. At the same time, parents must be shown that earning differentials within levels of education are nearly as great as between levels, and that youth with technical skills can, and in fact do, earn high salaries as technicians or entrepreneurs.

Encourage and Fund Innovation and Entrepreneurship at Colleges

Colleges employ many innovative and creative faculty and administrators who, given the opportunity, might find solutions to pressing problems and devise better education and training methods. The innovative programs described in this paper invariably are traceable to entrepreneurial and persistent administrators and faculty who conceptualized or adapted, and then advanced, the initiatives. Governments at all levels need to ensure that laws are flexible enough to allow colleges to adjust to local circumstances. If funds are tied only to enrollments, for example, there is little chance for faculty—most of whom have heavier teaching loads than university faculty—to work with SMEs. Incentives and opportunities for experimentation, learning, and innovation may produce tomorrow's policies. Entrepreneurship at and within colleges must be encouraged, not discouraged.

Include Colleges in Regional Planning Efforts

In addition to their contributions to the growth of the local economy, technical colleges, because of their connections to small and mid-sized businesses and information about labor and job markets and technological changes, also bring special perspectives to the region. Therefore, they ought to be integral to regional strategic planning teams, not just as advisors but as full partners.

VIII. Summary

Technical colleges are generally acknowledged as vital ingredients in regional technology and innovation strategies—retraining in the wake of technological change and ensuring a sufficient flow of technically proficient workers into the region to meet needs and allow for growth. Most colleges now include some dimensions of technology development within their core missions. Just how far a college is willing to extend its reach beyond its traditional student-client base towards a newer and less conventional business-client base depends on a number of factors, i. e., college and business leadership, national and state policies and regulations, budgets, alternative sources of technology training and assistance, degree of flexibility and autonomy, and entrepreneurial energy.

Some technical colleges have moved quickly down the road, paved by technology, toward regional economic goals, often resorting to semi-autonomous centers under the direction of the college but with sufficient independence to provide the flexibility required by businesses. The trend appears to be toward a more expansive role for colleges, not less. Technical colleges, which are regionally committed and connected, possess a store of technical expertise and knowledge, are able to adapt quickly to change, and are better able to successfully bridge the gap between civic and economic, individual and industry interests than most institutions. The major evidence is the views of employers, especially SMEs who look to contract with technical colleges for an increasing range of services.

IX. End Notes

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